MEASUREMENT OF PRECISION GEOMETRIC DISTANCES TO THREE ANCHOR POINTS IN THE LOCAL UNIVERSE

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Our program, funded by a NASA/SARA 3-yr grant, seeks to provide a much improved foundation for the extra-galactic distance scale. The goal is to measure geometric distances with accuracies of 5% or better to several anchor points in the Local Universe. There are three objects that we are observing in order to attack this problem: NGC 4258, M 33, and Sgr A*. We plan to provide distance estimates, with a minimum of systematic uncertainty, that can be used to re-calibrate several "standard candles," such as Cepheid and RR Lyrae variables. This will place the extragalactic distance scales on much firmer ground.

The program will provide crucial, independent checks and calibrations of extragalactic distance measurements, and will contribute to the ultimate success and impact of the HST
Key Project on Extragalactic Distances and any future NASA astrometric missions. Additionally, since distances are fundamental to astrophysics, our results will affect a large number of general projects on NASA facilities such as the HST, CXO, and JWST.

In the past year we have made substantial progress:

1) NGC 4258: Over the past year, we have combined the data from 23 VLBI observations over a period of 6 years. All of the data have been carefully scrutinized and the positions (with 10 micro-arcsec precision) and accelerations of all maser features have been finalized. Our postdoctoral fellow (Dr. E. Humphreys) has written a sophisticated 3-D modeling program and we have a preliminary distance estimate of 7.2 +/- 0.3 Mpc, including sources of systematic error. This corresponds to a 4% distance uncertainty, making it the most accurate extragalactic distance measurement. Two papers are being written that document these results. Work is continuing to improve this result.

2) M 33: We have completed the analysis of 2.5 years of VLBI data on the Triangulum Galaxy (M33). We have successfully measured the angular rotation rate of the galaxy by measuring the relative positions of two H2O masers in different star forming regions on opposite sides of the galaxy. We have achieved a proper motion accuracy of about 5 micro-arcseconds per year for each source. This is the first believable measurement of the angular rotation of a galaxy. A comparison of the angular rotation with the galaxy's known rotation speed and inclination (from HI observations), yields a direct measurement of its distance of 730 +/- 168 kpc. We are continuing to observe M33 and should have a much more accurate distance in the next few years.

3) Sgr A*: Our goal of obtaining a trigonometric parallax measurement accurate to better than 5% for the compact radio source at the center of the Milky Way (Sgr A*) appears unlikely to succeed. We have improved our calibration methods and are now achieving single-epoch position accuracy of about 50 micro-arcsec. It would take about a factor of three improvement to achieve our goal with a reasonable amount of observing time.

The reasons for our degraded accuracy (compared to other objects such as M33) are two fold: 1) Sgr A* is a very low declination (-29 degrees) which necessitates observing at low source elevations, and 2) Sgr A*'s image is scatter broadened to the point that we can only effectively use interferometer baselines shorter than 1500 km.

Overall, we have now demonstrated substantial progress toward meeting most of our very ambitious goals. The distance accuracy for NGC 4258 already has met our goal and probably will exceed it. We are confident that we will come close to achieving our goals for M33. These two accurate geometric distances should lead to a revision of the extragalactic distance scale and considerably strengthen its accuracy.